SD11
F6
1997
Mar.

d States
rtment of
Agriculture

Forest Service

Forestry Research West

March 1997

LIBRARY COPY
ROCKY MOUNTAIN RESEARCH STATION
FORT COLLINS CENTER

A report for land managers on recent developments in forestry research at the four western Experiment Stations of the Forest Service, U.S. Department of Agriculture

Forestry Research West

In This Issue

	Page
Insects/their relatives help forest stay healthy	1
The legacy of Santa Rita	4
Insects and ecosystem management	7
New from research	13

Cover

The legacy of the Santa Rita Experimental Range in southern Arizona goes back to the turn of the century. Results from grazing and other studies are being used today to develop grazing systems and other land management plans for semidesert regions throughout the world. Details begin on page 4.

To Order Publications

Single copies of publications referred to in this magazine are available without charge from the issuing station unless another source is indicated. See page 15 for ordering cards.

Each station compiles periodic lists of new publications. To get on the mailing list, write to the director at each station.

To change address, notify the magazine as early as possible. Send mailing label from this magazine and new address. Don't forget to include your Zip Code.

Permission to reprint articles is not required, but credit should be given to the Forest Service, U.S.D.A.

Mention of commercial products is for information only. No endorsement by the U.S.D.A. is implied.

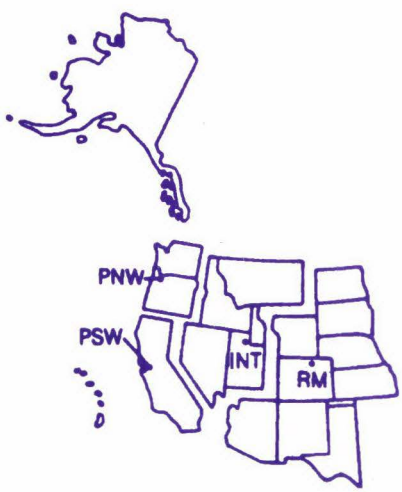
Western Forest Experiment Stations

Pacific Northwest Research Station (PNW)
333 S.W. First Avenue
Portland, Oregon 97204

Pacific Southwest Research Station (PSW)
P.O. Box 245
Berkeley, California 94701

Intermountain Research Station (INT)
324 25th Street
Ogden, Utah 84401

Rocky Mountain Forest and Range Experiment Station (RM)
240 West Prospect Street
Fort Collins, Colorado 80526-2098



Insects/their relatives help forest stay healthy

by Nancy Jacobson
for Pacific Northwest
Station

Note: Nancy Jacobson was a 1996 summer intern at The Oregonian *in Portland under the sponsorship of the American Association for the Advancement of Science. She holds a Ph.D. in entomology from Cornell University. This article was reprinted courtesy of* The Oregonian*; photos are by staff photographer Bob Ellis.*

Looking out over the H.J. Andrews Experimental Forest, you see a sea of green: patches of Douglas-fir plantations of different ages set within an old-growth forest.

And as you walk into that ancient stand, the ground underfoot is springy with mats of dead needles and moss on top of fertile soil and decaying logs. Following a deeply creviced trunk of a Douglas-fir up 160 feet, you see its sun-loving branches above the more shade-tolerant hemlock and redcedar.

But you probably don't notice the myriad of tiny and sometimes secretive insects and their relatives, or arthropods. The roles of these arthropods and what happens to them when the forest is disturbed, only now are beginning to be understood.

Arthropod species abound in the Andrews forest, 50 miles east of Eugene, Oregon. There are more than 3,400 described so far, compared with 143 back-boned animal species such as birds and mammals and 460 species of vascular plants, mainly conifers and flowering plants, according to John Lattin, director of the Systematic Entomology Laboratory at Oregon State University (OSU).

"In one square yard in a mature forest at Andrews, there are more than 100,000 individual oribatid mites," said Andrew Moldenke, an OSU entomologist who does research there.

"Without arthropods' influence in cycling nutrients, you could get some bottlenecks with all the nutrients tied up in trees or dead logs and not available for roots to take up," said Timothy Schowalter, an OSU ecologist who also is an Andrews forest researcher. "We think that's part of the problem with forest health in eastern Oregon. Most of the nutrients have gotten tied up, and now so many trees are competing for limited water and nutrients that something's got to start turning over that material and putting the nutrients back into the soil. The insects and diseases are helping to do that."

"The Andrews forest is healthy because it is on the western slope of the Cascades," said W. Arthur McKee, Willamette National Forest. The experimental forest is run jointly by the Pacific Northwest Research Station, Willamette NF (Blue River Ranger District), and Oregon State University. The Andrews forest was established by the USDA Forest Service in 1948 and is codirected by Fred Swanson, Pacific Northwest Research Station and McKee. Since its beginning, the forest has been used as an outdoor laboratory for ecosystem-oriented research and education.

In the Andrews forest, the 70-90 years of fire suppression typical of Forest Service land is within the normal range of time between natural fires. A healthy forest floor, 150 years old and more, is strewn with logs, often from being blown down during storms. But to break them down to return the nutrients to the soil is no simple task. The outer bark is full of waxes and defensive chemicals. Bark beetles are undeterred by these defenses and chew their way in. Termites can then follow. Both bark beetles and termites feed on the relatively nutritious and undefended inner bark during the first 2 years.

Bark beetles carry fungi into the log. The fungi and the termite's gut microorganisms can slowly break down the cellulose in the outer wood, the sapwood. The inner wood, or heartwood, is better protected chemically, especially in Douglas-fir and cedar, so it is not as susceptible to insects and fungi.

Eventually even it succumbs, and water can percolate throughout the log. Decaying logs provide nitrogen (a natural fertilizer) and water hot spots where other trees can start to grow. The skeletons that are left sink into the landscape, and you see them as rolling contours on

Bark beetles and termites feed first on the thin layer of inner bark of a decaying log just outside of the sapwood where the bracket fungi are growing. Photo credit: Bob Ellis, The Oregonian.

the forest floor. "If you do a soil core through an old-growth forest, what you find is that it's just log after log after log, centuries of logs," Schowalter said.

"Bug poop" grows trees

Moldenke takes a different view of soil. He looks at it under the microscope and sees living organisms, their fecal pellets and their dead carcasses. Moldenke likes to sum up the recycling done by soil arthropods as "bug poop grows trees."

In the litter, a particularly important arthropod for keeping nutrients recycling is the cyanide-producing millipede. It is found in all ages of forest at Andrews.

The millipede can chew dead needles and other leaves more quickly than other arthropods. Bits of leaves stay intact through digestion, making smaller pieces available for smaller mouths. After each pass-through, fungi and bacteria can attack the

tissue along the edges of these pieces, turning nutrients into forms a plant can use.

Moldenke said the millipede acts as a "can opener" for the fungi and bacteria's "canned food" of dead leaves.

Nutrients also are passed up the food chain before becoming available to the plants again. And even the best defenses aren't perfect. Shrews occasionally suck the blood from cyanide-producing millipedes, but the "agile butcher-jawed" ground beetle feeds solely on it. "The beetle paralyzes the millipede by pinching the nerve cord with its huge jaws," Moldenke said.

Schowalter has found that feeding arthropods up in the branches can increase soil fertility in young Douglas-fir plantations. Arthropods, such as sawfly larvae and some mites, that chew on needles, expose the trees' tissues to rain that washes nutrients to the ground.

Nutrients also are tapped by insects, such as aphids and scales, that suck the tree's fluids from its leaves. If there are not too many munchers and suckers, the trees compensate by growing more needles.

Many birds prey on canopy arthropods. But 30 percent of the total number of arthropods collected in the canopy are predators as well: spiders and certain mites, beetles, wasps, and flies. Schowalter has seen a predacious snout mite prying up the shell of a scale insect. About one-third of the scale insects in his canopy samples had escape holes made by adult parasitic wasps after spending their youth feeding on the scale's insides.

Plantations are not deserts

"The very early stages of clearcut, whether older trees are left or not, are by no means a biological desert," Moldenke said of soil and litter arthropods when the clearcut isn't burned or subject to erosion or soil compaction. Instead, he and others have found that the organisms often were just different.

In an old-growth forest, where the litter is deep, most spiders sit and wait for their prey to come by, often capturing them in small webs. The relative openness and greater light of the plantation is better for litter spiders that hunt visually and chase their prey.

Bees also are much more common in lit, open areas. They are important pollinators of understory plants, though most trees are pollinated by the wind.

Arthropods in young plantations can move around well, because they are adapted to finding widely separated open areas where trees have blown down or a fire has burned through. Old-growth forest, on the other hand, provides insects with diverse but constant conditions. Consequently, many of the arthropods there cannot fly.

This has implications for the forest fragmentation caused by logging. Clearcutting has largely stopped, but experiments still are being done to determine whether leaving trees singly or in clumps as refuges will allow movement between old-growth forest fragments.

Schowalter has found that trees 150 years old and older have 20 to 30 percent more arthropod species than do young plantation trees. That's because there is much greater variation in the succulence, toughness, and the amount of defensive chemicals in the needles at various levels of the canopy in the older trees. "If you lose 25 percent of the species, does it matter? It probably depends on which proportion you lose," Schowalter said. If species are left that do the same things as those that were lost, it may not matter too much unless climate changes or something else happens and those that were lost were better at surviving under the new conditions, he said.

The legacy of Santa Rita

by Al Medina and
Rick Fletcher
Rocky Mountain Station
USDA Forest Service

The Santa Rita Experimental Range (SRER), the oldest in the U.S, was established in 1903 in southern Arizona to protect the native rangeland from grazing and to conduct research on problems associated with livestock production. Accumulated information on ecology of the semidesert system at SRER is more complete than for any other tract of comparable size and diversity. Research results have worldwide applicability to other semidesert regions. Much of the current knowledge of range and wildlife management of semidesert grassland ecosystems is derived from SRER research.

The 53,159-acre range is located about 35 miles south of Tucson. It is characterized by small areas of steep, stony foothills and a few isolated buttes, but the greater part consists of long, gently sloping alluvial fans. Elevations range from 2,900 to 5,200 feet. Velvet mesquite is the dominant overstory species on 20,000 to 30,000 acres where shrub-free grassland dominated 80 years ago. Mesquite and prickly pear cactus are major species above 4,000 feet. Lower elevations are dominated by creosote bush.

A diverse fauna characteristic of the semidesert habitats is found on the SRER. Important game species include mule deer, white-tailed deer, collared peccary, Gambel's quail, scaled quail, morning dove, white-winged dove, and desert cottontail. Many other species of mammals, birds and reptiles are also common. Hunting, nature studies and bird watching are the principal recreational activities.

History

SRER was originally contained within the Santa Rita Forest Reserve, as established by Presidential Executive Order of April 11, 1902 by President Theodore Roosevelt. In 1905, the forest reserves were transferred to the Department of Agriculture and consolidated with the Bureau of Forestry to form the Forest Service. On July 1, 1910, President Taft transferred lands, then known as the Santa Rita Range Reserve, to the Bureau of Plant Industry, which was subsequently transferred to the Forest Service, Branch of Research, in 1915.

Research

Beginning around the turn of the century, range investigations centered on forage production, plant phenology, plant inventories, carrying capacity, erosion, livestock behavior and range conditions. Research objectives were to determine the period of time that would be necessary for the range to regain its productivity, and to determine the grazing capacity of such a range once it had reached a satisfactory condition. From 1900 to 1915, studies focused on the growth habits of important forage plants and grasses to determine the best methods of assessment, care and improvement of grazing lands. Scientists found that the species that lived longer on grazed plots were short grasses with mostly basal foliage. Plants living longer were mainly mid-grasses. These differences showed why the percentage of mid-grasses increases in response to moderate to light grazing, and decreases under heavy grazing. In 1915, studies included the relation of climate to range/plant growth and use, and methods of range management on semidesert ranges.

Between 1915 and 1940, investigations centered on range economics, betterment of livestock breeds and calf crops, and livestock management strategies. These efforts were driven by two major objectives: 1) to determine better methods for managing semidesert range lands, typical of Santa Rita, for the purpose of improving and maintaining them on a sustainable basis of productivity; and 2) to manage cattle to obtain the greatest annual returns. Cattle grazing systems were a major focuse of research. Scientists looked for the "ultimate" system designed to achieve more equitable utilization over the range, as well as among forage species. One particular study found that yearlong grazing at appropriate stocking levels is a reasonably good system. Many alternatives that were tried were not superior to yearlong grazing mainly

A 1932 study examined rodent consumption of range forage.

because recovery during rest periods was offset by the impact of more rapid forage removal during the grazing period.

During the 1940's, funds became available for basic research on the physiology and ecology of noxious range plants. Great attention was paid to undesirable species such as burroweed, cholla cacti, mesquite and prickly pear.

The 1950's and 1960's were a time of basic research on semidesert grasses. Various studies dealing with plant competition relationships, plant-drought interactions, and physiological response of mesquite to herbicides were initiated. Major emphasis was placed on control of mesquite,

burroweed and other undesirable species. Studies on one of the most undesirable plants—mesquite—showed that small plants, one inch in diameter or less, are best controlled by hand grubbing. Successful control of larger mesquite required bulldozers, chaining or cabling. Scientists also found that applying diesel oil or kerosene will kill mesquite. Other studies focused on airplane spraying and broadcast burning.

Since 1975, research on semidesert grasslands has been de-emphasized in light of other issues such as wildlife-livestock interactions, production and utilization of Lehmann's lovegrass, cattle foraging behavior, and small mammal habitat interactions. Extensive research has focused on rodent habitats, insects, quail, javelina, coyotes and deer.

SRER today

Santa Rita continues to function as an outdoor laboratory, providing study areas for various research cooperators. Research planning and administration is coordinated by the Santa Rita Research Committee which includes members from the University of Arizona, USDA Science and Education Administration, Coronado National Forest and the USDA Forest Service Rocky Mountain Forest and Range Experiment Station. Final responsibility rests with the latter agency.

SRER is available to scientists for conducting research. If interested, contact the Department of Renewable Natural Resources, 325 Biological Sciences East, University of Arizona, Tucson, AZ 85721, (602) 621-7255.

An annotated bibliography of research publications, dating back to 1901, is now available from the Rocky Mountain Station as *The Santa Rita Experimental Range: History and Annotated Bibliography (1903-1988),* General Technical Report RM-276. Most of the references in the bibliography are in the U of A Library under special collections. They contain valuable insight into range and forest conditions in the western United States. Many accounts describe the problems that resource managers were faced with at the time. Nearly every forest in the Southwest is described in terms of problems related to grazing, tree production and watershed condition. Also included are original records of research data, hand-written notes from respective scientists, and maps showing locations of the study plots on SRER. This information is invaluable for conducting long-term evaluations of flora and fauna of the semi-desert grasslands of the Southwest.

Insects and ecosystem management

by Michael I. Haverty, Patrick J. Shea, and Connie Gill
Pacific Southwest Station

California, Oregon and Washington contain forests of extraordinary beauty and enormous commercial value. For many years California has been one of the top three lumber-producing states in the nation, yet, nowhere is the competition for forest resources more intense or more controversial.

Abundant forest resources were available during California's early history. The general mode of thinking was that the supply would last forever. Today, rapid population growth has placed alarming demands on these resources and now, although it's a top producer, California imports nearly 60 percent of the timber it uses.

More than 30 million people live in the State; their resource values are complex, diverse and dynamic. Demands for amenity values are increasing rapidly as urban development encroaches upon the wildland. These demands often create conflicts with the traditional uses of forests, compounded by a high per capita consumption of wood fiber and other natural resources. Awareness of environmental issues in California is intense. Residents are concerned about timber harvesting activities, but have difficulty connecting these management scenarios with everyday use of forest products.

Over the last few years, the public has become increasingly vocal about land-use issues. Land usage patterns driven by production values are being challenged and replaced by more holistic values. Federal land management agencies are attempting to meet these changing needs and values. Concern for threatened and endangered species has led to a reduction in the land base for timber production in the West, requiring more efficient use of wood and wood products. Forest management is shifting from clear cutting for even-aged stands to uneven-aged management. In addition, many forest plans are addressing nonconsumptive commodities such as recreation, wildlife habitat, and watersheds, rather than timber, minerals, and grazing.

Harvest restrictions have left many forests overstocked because they were planted or managed using silvicultural tactics that are no longer acceptable to the public. Overstocked forests, combined with encroachment of people within the urban-wildland interface, places trees under extreme stress, resulting in increased insect infestation.

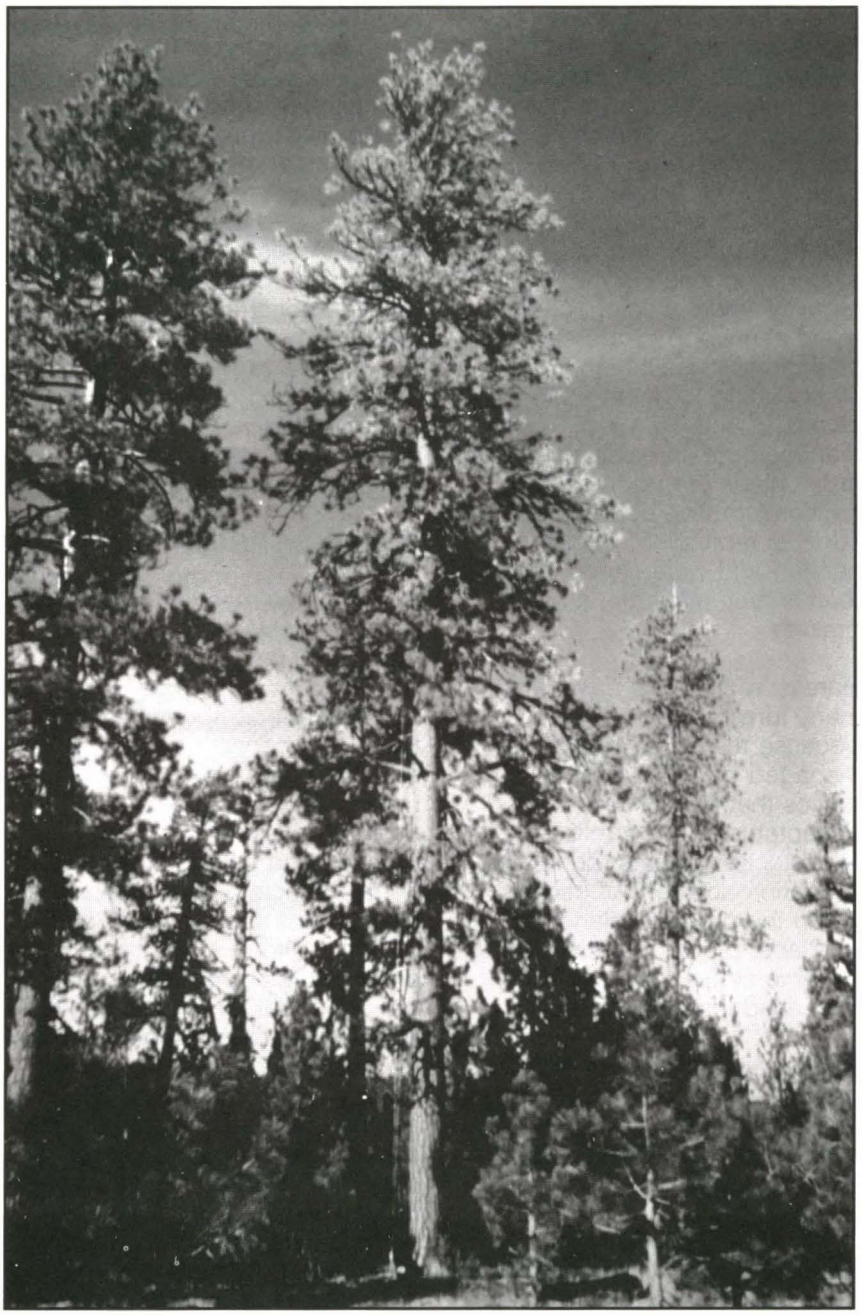
Insects are usually perceived as detrimental to a forest. However, insects are not always pests, are not always bad, and tree losses are not always detrimental events.

Entomologists with the Pacific Southwest Research Station are working to discover answers to the complex issues of insect behavior and their relationship to forest ecosystem health.

Scientists are encouraging a different attitude toward insects and their effects in wildlands. Although insects cause mortality in forests and can even cause severe losses to commercial timber, they can also enhance wildlife habitat and secondary productivity. This new perspective requires a better understanding of this balance and the positive functions of insects in forest ecosystems.

Insect benefits

Insects have many beneficial roles in forests and wildlands. Defoliating insects often reach epidemic levels and can denude a significant component of the forest tree canopy, or may even affect the success of regeneration. However, defoliators also serve as a primary food source for many wildlife species. Bark beetles can affect forest stand density and diversity, and in some cases, create snags or openings that are beneficial for wildlife habitat. Wood-degrading insects (termites, wood-inhabiting beetles, and carpenter ants) are among the predominant decomposers of large pieces of wood in the Sierra Nevada Ecoregion. They usually follow bark beetles in the succession of organisms contributing to the early stages of tree degradation. When successfully established, they greatly accelerate the



Ponderosa pine killed by western pine beetle attracted to trees by aggregation pheromones for snag creation.

decomposition process. Along with wood-degrading fungi, dampwood termites weaken root systems and woody tissues to hasten the conversion of standing, dead trees into coarse debris on the forest floor. This transformation drastically alters wildlife habitat as it imparts nutrients to forest soils. In natural ecosystems, insects influence recycling of organic matter, improvement of soil structure, regulation of pest populations, and tree mortality.

Forest managers can manage wisely and avoid problems if they have a working understanding of what organisms are present (biodiversity), the critical roles they play, and what their ecological requirements are. Lack of this knowledge can lead to errors that adversely affect the positive roles and accentuate negative roles.

Scientists believe that actions to control tree mortality should be as environmentally sensitive as possible. Today's forest managers and pest management specialists need cheaper, more effective, more ecologically based and less risky methods to reduce damage by insect pests.

To help meet those needs, entomologists with the Station's Chemical Ecology of Forest Insects research work unit will investigate the chemical aspects of insect behavior (the chemical communication between forest insects of the same species and other species within their

environment/habitat) to understand the biology and ecology of key species, and develop means for managing insect pests when necessary. To achieve this goal, they are addressing three problem areas.

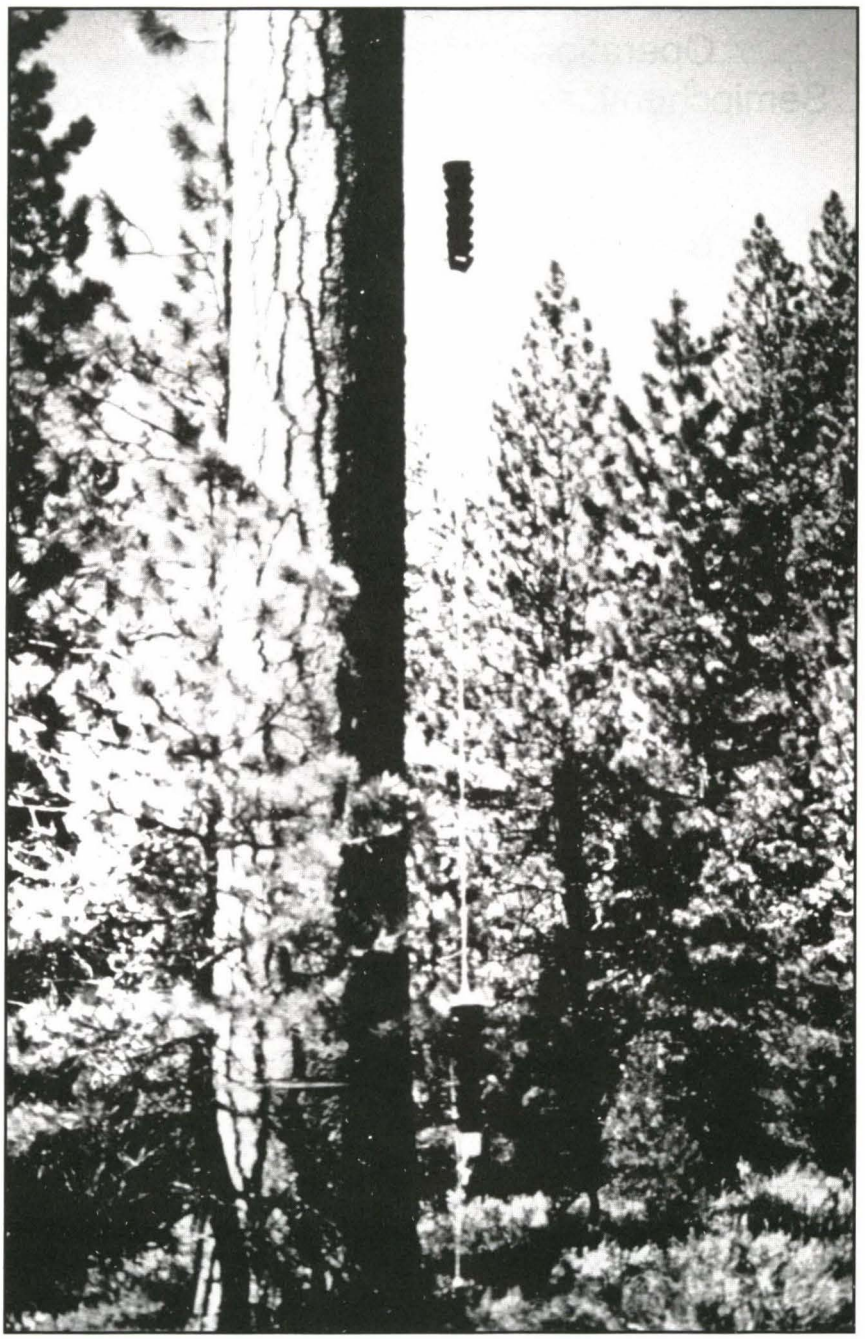
Problem #1

More information on the roles and impacts of insects in forest and wildland ecosystems is needed to maintain healthy, productive forest environments.

Pest management tactics that are environmentally sound and effective will become available to pest management specialists during the next decade. Instead of relying on the application of large quantities of broad-spectrum chemical insecticides, pest management specialists may be able to use more sophisticated or environmentally friendly approaches, such as pheromone or other behavior-modifying chemicals.

Solution

Research in this area focuses on the function of insects in forest and wildland ecosystems. Scientists will concentrate on the role of bark beetles in production of snags and/or openings in forest stands (wildlife habitat), and the role of wood-degrading organisms in the recycling of nutrients and reduction of coarse, woody debris. They will follow the life of a tree once it is



Pheromone traps—Lindgren traps.

Operational Implementation of Semiochemical-Based Management Since 1970

- Mass trapping
- Containment and concentration of infestations
- Post-harvest trapping
- Disruption or prevention of infestations

Strategies of bark beetle management using semiochemicals.

fatally attacked by bark beetles to see what happens until it returns to the soil. They will investigate the dynamics of everything connected with the tree, ie. bird and small mammal utilization, arrival and colonization of secondary insects, so accurate informed recommendations can be made for forest managers.

Problem #2

Taxonomy, behavior, and life histories of insects in forest and wildland ecosystems are essential in developing safe, effective pest management strategies.

Frequently it is difficult to identify insects that damage forest resources. In other words, knowledge of the taxonomy of many important forest insects is obsolete and in need of revision. The use of pheromone-based monitoring systems or pest management systems requires exact identification of insect species, subspecies, or biotype to accurately characterize the pheromone or other semiochemicals to be used.

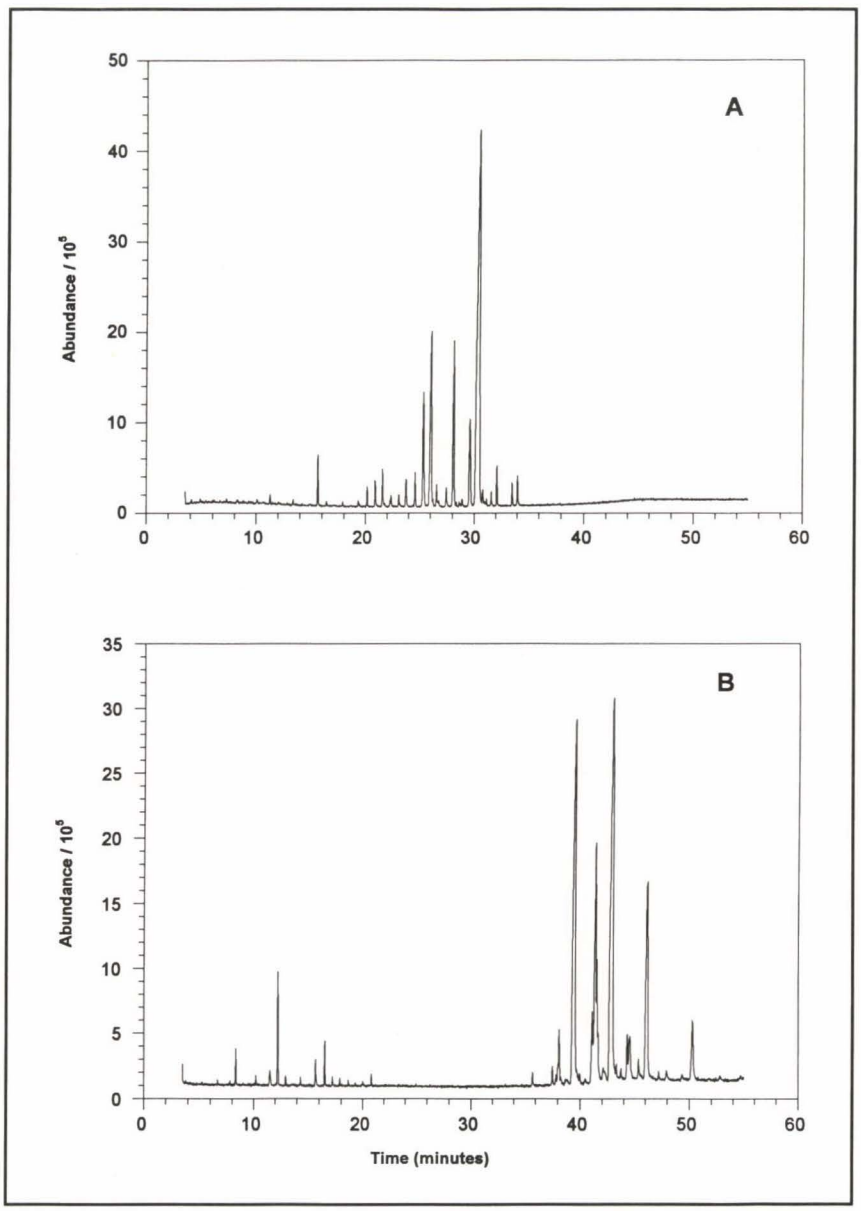
For decades, forest entomologists have had a basic understanding of the roles of some important semiochemicals in forest insect biology and their potential in pest management applications. Semiochemical-based pest management has only recently become an economically feasible reality because of changes in public perception, advances in pheromone synthesis and analytic chemistry procedures, new neurophysiological assays, and technological improvements in pheromone formulation and release devices. It remains the challenge of the scientific community to develop semiochemical-based methods for forest ecosystems and to demonstrate their efficacy to forest managers and to the public. Similarly, new analytical techniques, such as those used in molecular biology and cuticular hydrocarbon characterization, have opened new approaches to the study of taxonomy.

Solution

Investigations are helping understand the chemical ecology of forest insects. Morphological variation often leads to questionable species determinations in many ecologically important groups of forest insects. First, as an adjunct to classical taxonomy based on morphology, scientists will use the chemotaxonomic technique of characterizing cuticular hydrocarbons for discriminating species of forest insects. Pioneering work by Station scientists shows that in many genera, hydrocarbon mixtures can be correlated with insect species determinations. Conversely, new taxa have been recognized on the basis of unique hydrocarbon profiles. Whenever possible, cuticular hydrocarbon profiles and morphological descriptions will be complemented by genetic analyses. Second, behavioral studies will enable scientists to identify important behavioral

chemicals for these taxa, and integrate them into environmentally sound, effective pest management systems. Both insect pheromone and attractants produced by the hosts (kairomones) will be studied, as well as possible insect allomones mediating insect-plant interactions. Third, basic ecological and life-history studies of important forest insects are essential for the identification of "weak links" in insect life histories that render them vulnerable to population manipulation. Furthermore, such studies are critical in managing forests wisely and avoiding problems due to lack of adequate knowledge of key components of forest ecosystems.

Characterization of the cuticular hydrocarbons of insects is a new technology under investigation. All insects are covered by a waxy coating. The primary function of this outer layer is to prevent water loss. It is composed of about 90 percent hydrocarbons. They are removed by soaking the insects in hexane. The extract is then purified and concentrated. A small amount is injected into a gas chromatograph to separate the hydrocarbons on the basis of their boiling point.



Total ion chromatograms of the cuticular hydrocarbons of workers of (A) Nasutitermes costalis *and (B)* Nasutitermes acajutlae *from the British Virgin Islands.*

The theory underlying this technology is that each species within a group of related species will have a unique mixture of hydrocarbons. The presence or absence of abundant and highly modified hydrocarbons is used to separate insects into groupings that correlate with discrete species. Once the insects are

separated on the basis of cuticular hydrocarbons, corresponding morphological differences are found that can be used more easily to identify specimens to species.

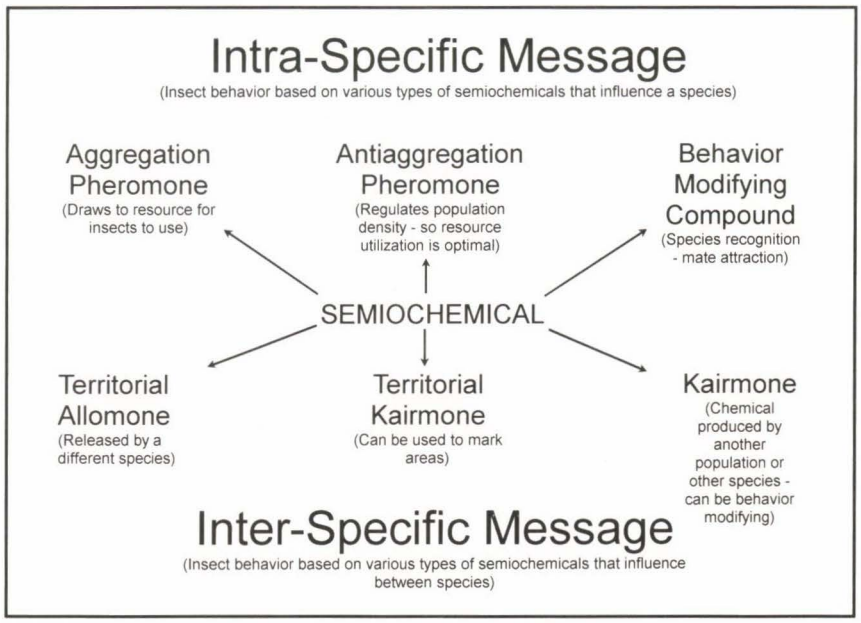
Problem #3

Methods are needed to detect, monitor and manipulate insect populations in forest and wildland ecosystems.

Once semiochemicals are characterized, devices must be developed to detect and monitor populations of pestiferous and beneficial insects. Once a decision has been made to influence an insect population, methods are needed for manipulating the population below or above the critical or desired threshold, and for maintaining the population at the appropriate level. Detection and monitoring methodology, appropriate population thresholds, and methods for manipulating populations must then be packaged into decision support systems for population management programs. The public will benefit from reduced cost of pest management and improved esthetics of forests and wildlands.

Solution

Scientists are concentrating on two primary lines of research. The first is the development of monitoring systems and devices to assess populations of detrimental and beneficial forest insects. This will rely on characterization of semiochemicals and development of trapping strategies. The second area is the development of population manipulation techniques. This will include evaluating chemical pesticides and alternative control techniques and devices for protection of high-value trees. More refined techniques will exploit semiochemicals to reduce damage by insects using mating disruption, mass-trapping, toxic trap tree, "bait-and-switch," and "push/pull" strategies. The ultimate product will be decision support systems for management of bark beetles. Scientists are also working to understand how to initiate increases in insect populations, how to turn off the enhancement, when it is appropriate or inappropriate to use this technology, and when such technology will or will not work.


Intra-Specific Message
(Insect behavior based on various types of semiochemicals that influence a species)
Aggregation Pheromone
(Draws to resource for insects to use)
Antiaggregation Pheromone
(Regulates population density - so resource utilization is optimal)
Behavior Modifying Compound
(Species recognition - mate attraction)
SEMIOCHEMICAL
Territorial Allomone
(Released by a different species)
Territorial Kairmone
(Can be used to mark areas)
Kairmone
(Chemical produced by another population or other species - can be behavior modifying)
Inter-Specific Message
(Insect behavior based on various types of semiochemicals that influence between species)

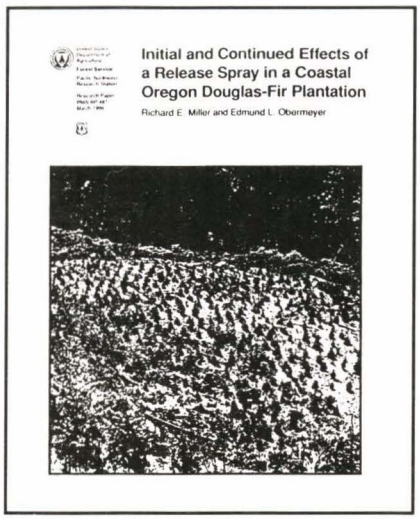
Insect behaviors based on semiochemicals that influence a species.

Conclusion

This work will add to overall forest insect knowledge and lead to better understanding of forest entomology. A new link associated with insect behavior may be discovered that can be used to enhance or stiffle insect activities. This research, through cooperation with other units at this and other Stations, universities, state agencies and private corporations, will help evaluate other information products and enhance forest insect chemical ecology.

New from research

Effects of herbicides on coastal Oregon Douglas-fir


Initial and Continued Effects of a Release Spray in a Coastal Oregon Douglas-Fir Plantation
Richard E. Miller and Edmund L. Obermeyer

Portions of a 4-year-old Douglas-fir plantation were sprayed with herbicide. Five years after spraying, 18 plots were established and it was later determined that six of the plots probably received full spray treatment and six others received no spray. Various portions of the remaining six plots probably were sprayed. Herbicide reduced the number and size of red alder, increased the number and size of planted Douglas-fir, damaged terminal shoots of Douglas-fir resulting in more abnormal boles and branching, and increased the number of volunteer conifers.

Fifteen of the eighteen plots were thinned. In the subsequent 6 years, thinned plots that had received full release at age 4 averaged 9 percent more volume growth (all species) than plots not released.

The report, *Initial and Continued Effects of a Released Spray in a Coastal Oregon Douglas-fir Plantation,* details this study. Request Research Paper PNW-487, from the Pacific Northwest Research Station.

A problem analysis of ecosystem management

Institutional Barriers and Incentives for Ecosystem Management: A Problem Analysis
Hanna J. Cortner, Margaret A. Shannon, Mary G. Wallace, Sabrina Burke, and Margaret A. Moote

Ecosystem management is currently being proposed as a new resource management philosophy. This approach to resource management will require changes in how society approaches nature, science, and politics. Further, if efforts to implement ecosystem management are to succeed, institutional issues must be examined. This report identifies five problem areas where social science research can improve our understanding of how ecosystem management can best be implemented. These include (1) the extent to which existing laws, policies, and programs may constrain or aid the implementation of ecosystem management; (2) institutional mechanisms for managing across resource agencies and the public; (3) internal organizational changes and new arrangements among resource agencies and the public; (4) theoretical principles underlying natural resource management; and (5) methodological approaches for researching institutional questions. Strategies to begin researching these questions also are suggested.

Request *Institutional Barriers and Incentives for Ecosystem Management: A Problem Analysis,* General Technical Report PNW-354, from the Pacific Northwest Research Station.

Conference proceedings on adaptive ecosystem restoration and management issued

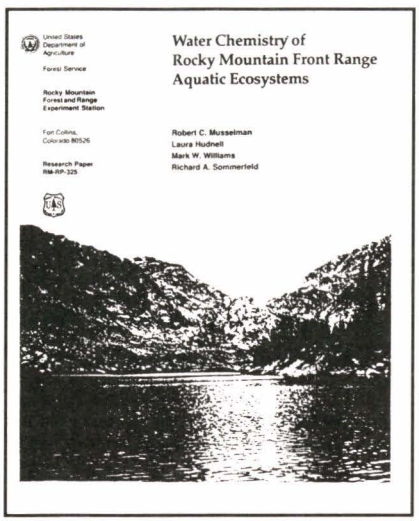
A conference was recently held in Flagstaff, AZ to facilitate the development of mutually beneficial human–wildland interactions. Papers focused on exploring ways to restore and sustain land health, as well as that of dependent human communities, in an adaptive ecosystem management context.

Although general adaptive ecosystem restoration and management principles were discussed, the conference was specifically designed to encourage cooperative North American work, and to aid in the development of mutualistic interactions between land managers, researchers, administrators and other individuals and organizations concerned with ecosystem restoration.

The primary focus was on long-needled pine and mixed conifer landscape systems of the Cordilleran region of North America.

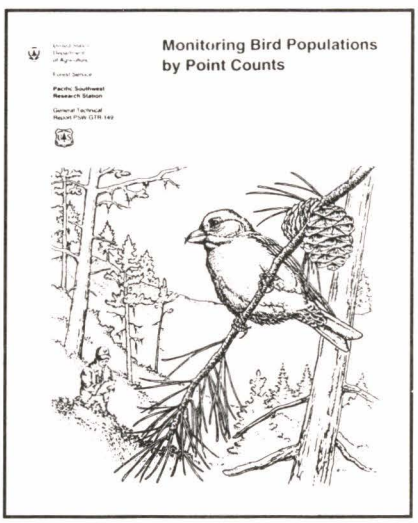
Copies of *Conference on Adaptive Ecosystem Restoration and Management: Restoration of Cordilleran Conifer Landscapes of North America*, General Technical Report RM-278, are available from the Rocky Mountain Station.

Water chemistry of Colorado Rocky Mountain Front Range aquatic ecosystems



A new report details a study of the water chemistry of Colorado Rocky Mountain Front Range alpine/subalpine lakes and streams in wilderness ecosystems, and their sensitivity to atmospheric deposition, particularly nitrogen saturation. The data base includes over 265 samples from more than 130 lakes and streams. Preliminary results indicate that many lakes have detectable nitrate concentrations which are higher early in the season and decrease as the season progresses. Inlets often have higher nitrate concentrations than outlets. For a copy of *Water Chemistry of Rocky Mountain Front Range Aquatic Ecosystems*, Research Paper RM-325, write the Rocky Mountain Station.

Monitoring bird populations by point counts



Point counts of birds is the most widely used quantitative method and involve an observer recording birds from a single point for a standardized time period. In response to the need for standardization of methods to monitor bird populations by census, various investigators met at the Symposium on Monitoring Bird Population Trends by Point Counts, November 6–7, 1991, in Beltsville, Maryland.

To order any of the publications listed in this issue of *Forestry Research West,* use the order cards below. All cards require postage. Please remember to use your Zip Code on the return address.

Please send the following Pacific Northwest Station publications:
(Circle the number)

1) Instutitional Barriers and Incentives for Ecosystem Management: A Problem Analysis, General Technical Report PNW-354
2) Initial and Continued Effects of a Released Spray in a Coastal Oregon Douglas-fir Plantation, Research Paper PNW-487
3) Other _____

Send to: _____

Please send the following Rocky Mountain Station publications:
(Circle the number)

1) Conference on Adaptive Ecosystem Restoration and Management: Restoration of Cordilleran Conifer Landscapes of North America, General Technical Report RM-278
2) Water Chemistry of Rocky Mountain Front Range Aquatic Ecosystems, Research Paper RM-325
3) Other _____

Send to: _____

Please send the following Intermountain Station publications:
(Circle the number)

1) Other _____

Send to: _____

Please send the following Pacific Southwest Station publications:
(Circle the number)

1) Height-Diameter Relationships for Conifer Species on the Blacks Mountain Experimental Forest, Research Note PSW-418
2) Grazing on Regeneration Sites Encourages Pine Seedling Growth, Research Paper PSW-223
3) Monitoring Bird Populations by Point Counts, General Technical Report PSW-149
4) Other _____

Send to: _____

STAMP

Rocky Mountain Forest and Range Experiment Station
3825 E. Mulberry
Fort Collins, Colorado 80524

(Attn: Publications Distribution)

STAMP

Pacific Northwest Research Station
333 S.W. First Avenue
Portland, Oregon 97204

(Attn: Publications Distribution)

STAMP

Pacific Southwest Research Station
3825 E. Mulberry
Fort Collins, Colorado 80524

(Attn: Publications Distribution)

STAMP

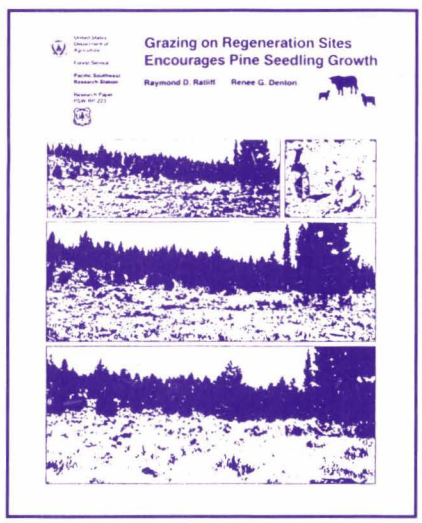
Intermountain Research Station
324 25th Street
Ogden, Utah 84401

(Attn: Publications Distribution)

Statistical aspects of sampling and analysis were discussed and applied to the objectives of point counts. Symposium participants agreed upon standards of point counts that should have wide applicability to a variety of habitats and terrain.

For a copy of the proceedings, request *Monitoring Bird Populations by Point Counts*, General Technical Report PSW-149, from the Pacific Southwest Research Station (at its distribution center at Fort Collins, Colorado).

Grazing encourages pine growth



Cattle grazing can be a useful tool for managing regeneration sites. The effects of season-long, deferred-rotation, and rest-rotation grazing on conifer seedling growth and herbaceous vegetation control were recently studied at Boyd Hill, Modoc National Forest, in northern California from 1989 to 1993.

Wildfire burned the area in 1978. Regeneration sites were prepared in 1988, and ponderosa pine seedlings were planted in 1989. Take-down fences were used to simulate deferred-rotation and rest-rotation grazing in a randomized complete block design on five sites.

Pine seedling survival and damage did not differ among treatments, but the seedlings were significantly taller, with longer leaders with season-long grazing than without grazing. Improved range conditions (1989 to 1993) reflected natural recovery from site disturbance. Treatment comparisons (1993) of plant group and nonplant percent cover differed only for litter and bare soil, but the differences were not between season-long grazing and no grazing. Cover and percent composition of bottlebrush squirreltail were greater without grazing than with season-long grazing. Soil surface movement (except in the first year) and residual herbage amounts did not differ between treatments.

Request your copy of *Grazing on Regeneration Sites Encourages Pine Seedling Growth*, Research Paper PSW-223, from the Pacific Southwest Research Station (at its distribution center at Fort Collins, Colorado).

Height-diameter relationships for conifers

Foresters often need estimates of total tree heights when only the diameters of the trees are known. An equation has been developed to predict total height as a function of diameter outside bark at breast height. This measurement was designed for use on conifer species, eastside pine type, at the Blacks Mountain Experimental Forest in northeastern California.

Weighted nonlinear regression was used to estimate the equation coefficients. The equation, along with the species-specific regression coefficients, provides a reliable basis for estimating missing heights on inventory and growth plots. However, if the equation is used to estimate heights of trees larger than those in the data base, or if it is used outside the Blacks Mountain Experimental Forest, the reliability of such estimates are unknown, since they would have been made with extrapolations of the basic data. Also, heights of trees with broken, dead, or severely deformed tops should not be estimated with this equation.

Request *Height-Diameter Relationships for Conifer Species on the Blacks Mountain Experimental Forest*, Research Note PSW-418, from the Pacific Southwest Research Station (at its distribution center at Fort Collins, Colorado).

FORESTRY RESEARCH WEST
U.S. Department of Agriculture
Forest Service
240 West Prospect Rd.
Fort Collins, Colorado 80526

Official Business
Penalty for Private Use, $300

BULK RATE
POSTAGE & FEES PAID
USDA – FS
Permit No. G-40